Blue-Green Algae in Wisconsin: Results of a Two-Year Statewide Monitoring Program

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Introduction

-Under certain conditions, blue-green algae can increase in number to “bloom” densities.

-Factors that may be involved include:

Monona Golf Course Pond

-Nutrients
  -P; some can fix N
  -recent studies: N just as important
-Temperature
-Water depth
-Wind
  -calm, low turbulence
  -gas-filled vesicles (most)
-Zebra mussels
  -filter water → deeper pen. sun.
  -eat all except blue-green algae

Introduction

Issues Associated with Blue-Green Algae Blooms

-Discolored water

-Taste and odor problems

-Reduced light penetration

-Dissolved oxygen depletions during die-off

-Toxin production

Introduction

Blue-Green Algal Toxins

Red Cedar R.

-Some species can produce one or more toxins

-Those that can produce toxins do not produce toxins at all times (genetic strain, environmental conditions)

-Toxins can affect

- -Fish and other aquatic life
- -Livestock (reports of deaths date back to 1878)
- -Pets (reports of dog deaths widespread)
- -Humans (70 deaths in Brazil, 1996; 1 in WI, 2002)

-Exposure routes in humans: dermal, oral (water or food), inhalation, dialysis

Dermatotoxins and Gastrointestinal Toxins

-Affect skin and mucous membranes
-Can cause rashes, respiratory illness, headaches, gastrointestinal upset
-lyngbyatoxin, lipopolysaccharide endotoxins

Hepatotoxins

-Affect the liver (cell membrane integrity)
-Can cause hemorrhage, tissue damage, tumors, liver cancer, death
-microcystins, nodularins

Cytotoxins

-Affect the liver and other organs (protein synthesis)
-Can cause chromosome loss, DNA strand breakage, damage to organs
-cylindrospermopsin

Neurotoxins

-Affect the central nervous system (acetylcholinesterase, sodium channels)
-Can cause seizures, paralysis, respiratory failure, death
-anatoxin-a, saxitoxin

Introduction

Guidelines

-Currently no surface water quality criteria, no drinking water standards in U.S. for blue-green algae or for blue-green algal toxins

-World Health Organization guidelines:

100,000 cells/mL = moderate risk to human health

1 µg/L microcystin-LR = drinking water guideline

Background on WI's BGA Monitoring Program

2003

-Limited monitoring conducted for *Cylindrospermopsis sp.*
-Sampled 31 eutrophic lakes
-Cylindro detected in 6

Cylindrospermopsis sp.

2004

-While planning to repeat study received reports of dogs dying (early June)
-High concentrations of *Anabaena* sp. (and anatoxin-a)
-Decided to expand study

Sampling Design

Lakes

5 lakes in each of 5 regions,
5 sample time points

Ponds

8 ponds in SCR only,
5 sample time points

*Most locations selected were eutrophic or known to experience blooms; many were beaches; all were accessible by the public.
NOT a random sample of lakes and ponds.

Sampling Methods

-Three samples were collected near shore at each location

-BGA ID and enumeration (plastic, preserved)
-chlorophyll-a analysis (plastic, in dark, on ice)
-blue-green algal toxins analysis (amber glass, on ice)

-Shipped overnight to WI State Laboratory of Hygiene

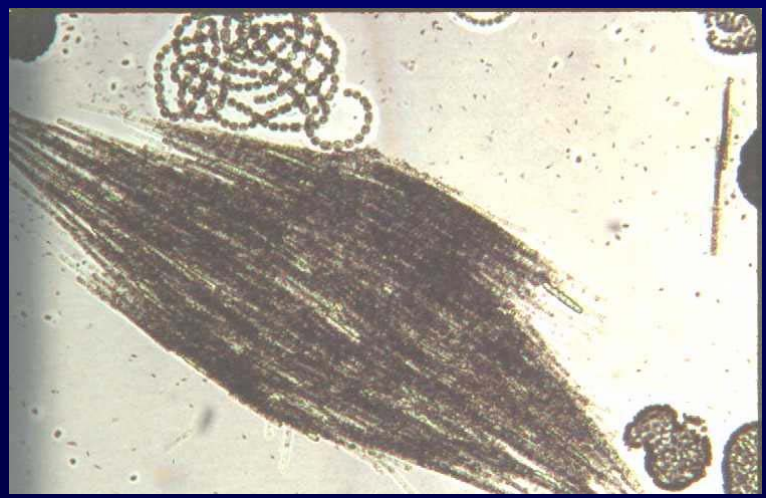
Identification and Enumeration Methods

Tier I Analysis

-all samples
-nanoplankton chamber
-rough estimate in natural units/mL

Tier II Analysis

-select number of samples
-Utermöhl settling chamber
-cells/mL and biovolume (mm^3/m^3)

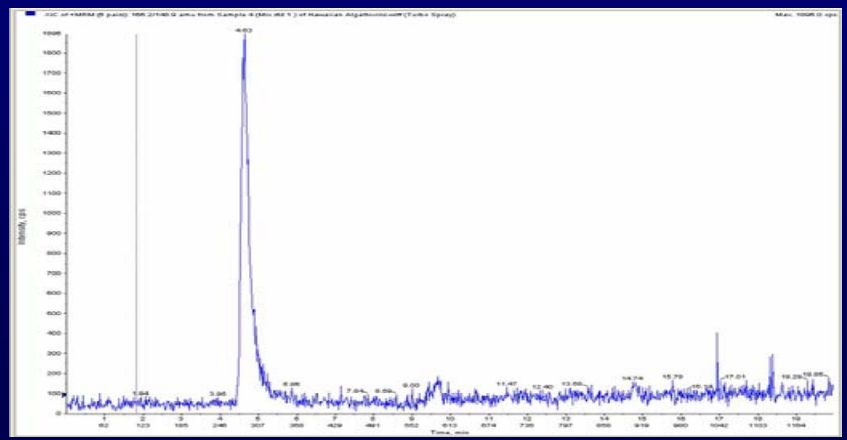


Analytical Methods

-Blue-green algal toxin analysis was performed by HPLC/MS/MS

-Three toxins in one run

-Report limits were 0.50 µg/L for anatoxin-a and cylindro-spermopsin, and 1.00 µg/L for microcystin-LR



Results

2004:

31 lakes	148 samples
10 ponds	38 samples
1 river	1 sample
Total:	187 samples

2005:

38 lakes	154 samples
8 ponds	35 samples
1 river	5 samples
Total:	194 samples

(each site sampled 1 to 6 times)

L. Kegonsa

Results: Blue-Green Algae

2004:

BGA detected in 138/187 samples = 74%
Hot spots: SCR and WCR

2005:

BGA detected in 143/194 samples = 74%
Hot spots: SCR and WCR

L. Menomin
2004
microcystin

Colladay P.
2004 & 2005
anatoxin-a

Results: Toxins

Number of samples analyzed

2004: 45/187 samples = 24%

2005: 34/194 samples = 18%

(Note: selected samples with high concentrations of BGA)

Results: Toxins

2004: 31/45 samples

anatoxin-a	in 5	1.5 – 110 µg/L
microcystin-LR	in 26	1.2 – 7,600 µg/L

2005: 14/34 samples

anatoxin-a	in 3	0.68 – 2.7 µg/L
microcystin-LR	in 13	1.2 – 450 µg/L

Guideline Values

anatoxin-a	3 µg/L
microcystin-LR	1 µg/L

Results: Toxins

Relationship Between Toxins and Blue-Green Algae

-Concentration of microcystin **was not** significantly correlated to the sum concentration of those species of blue-green algae (in natural units/mL, cells/mL, or mm3/m3) capable of producing microcystin (5 species).

-Concentration of microcystin **was** significantly correlated to concentration of *Microcystis* sp.

L. Maria

Results: Chlorophyll-a

-Concentration of Chl-a ranged from 2.26 – 126,000 µg/L(!)

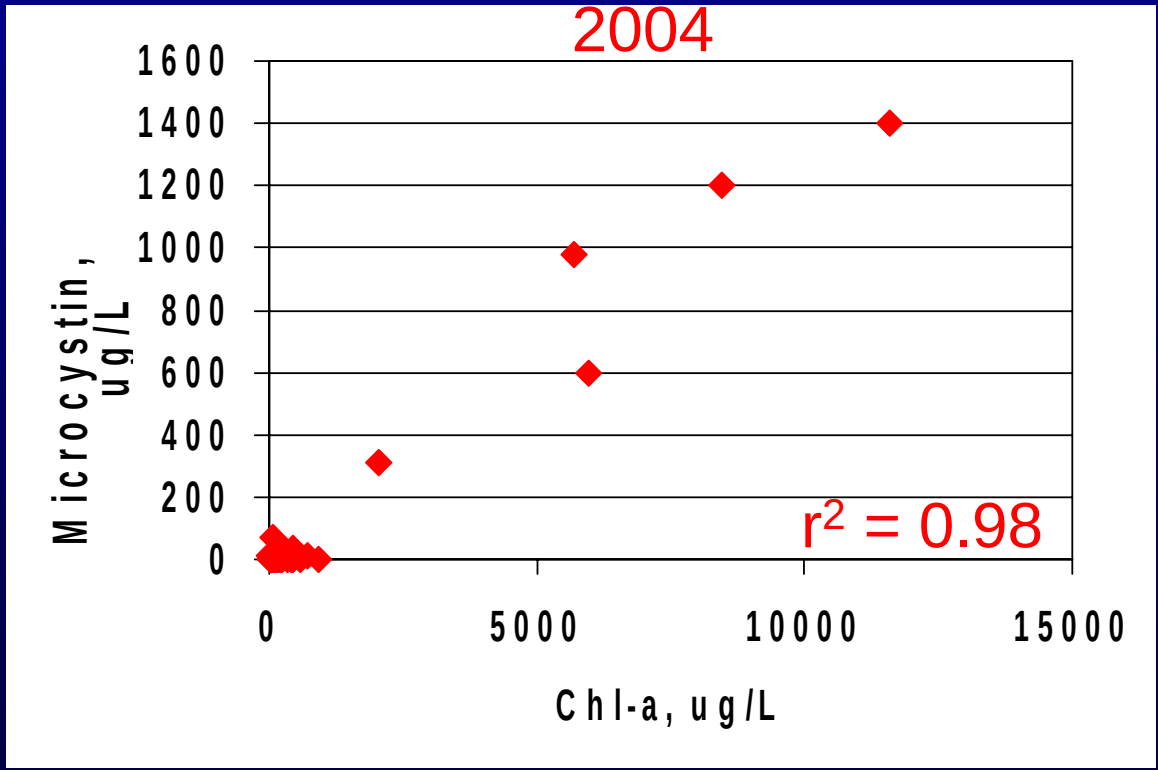
Relationship Between Chl-a and Blue-Green Algae

-In general, concentration of chl-a **was** significantly correlated with concentration of blue-green algae (natural units/mL, cells/mL, or mm^3/m^3), but r^2 values were low.

Results: Chlorophyll-a

Relationship Between Chl-a and Toxins

-Concentration of Chl-a was significantly correlated with concentration of the toxin, microcystin.



2005 r^2 = 0.31

Information Sharing

-Program not designed to provide real-time information

-Sent letter and background info to public health officers

-Results shared with local and state public health agencies when Tier I analysis showed sum concentration BGA > 5,000 natural units/mL (33 alerts in 2004; 42 in 2005)

-Only the public health agencies have authority to close or post beaches (responses differed by counties)

Information Sharing

Response by Local Public Health Departments

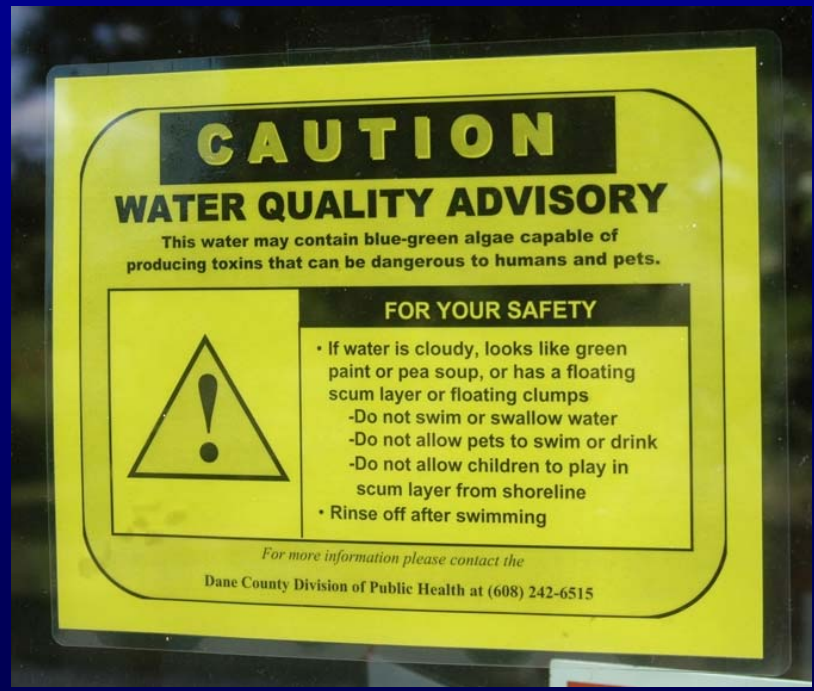
-Some closed/reopened beaches

-Some posted advisory signs

-One obtained funds to do additional sampling

-All who posted used our generic advisory sign

-Almost all called and asked for more information



Information Sharing

Samples Counted in cells/mL (end of season)

2004:

>5,000 natural units/mL: 22

20 > 100,000 cells/mL

<5,000 natural units/mL: 13

2 > 100,000 cells/mL

2005:

>5,000 natural units/mL: 25

24 >100,000 cells/mL

<5,000 natural units/mL: 9

1 >100,000 cells/mL

Research Needs

-Development of threshold values or criteria for blue-green algae and their toxins (WHO values based on *Microcystis sp.* and microcystin-LR toxin concentrations only)

-Development of analytical methods to analyze additional toxins we suspect may be present (e.g., anatoxin-as, BMAA, saxitoxin)

-Studies on the effectiveness of nutrient management plans in reducing the frequency, duration, and severity of blue-green algae blooms

-Studies on the persistence of toxins in water after bloom subsides

-Studies on bioaccumulation of toxins by freshwater fish (BMAA?)

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